# National Park Service Coastal Visitor Impact Monitoring
# Phase 2 Preliminary Report

By

*Christopher Monz*, Ph.D.
Principal Investigator
St. Lawrence University
Canton, NY 13617

And

*Yu-Fai Leung*, Ph.D.
Co-Investigator
Parks, Recreation and Tourism Management
North Carolina State University
Raleigh, NC 27695-8004

With Assistance Provided By –

*Heather Bauman*,
Research Associate
Sterling College
Craftsbury Common, VT 05827

And

*Christine Ingle*,
Graduate Research Assistant
Parks, Recreation and Tourism Management
North Carolina State University
Raleigh, NC 27695-8004

July 15, 2003

## I- Project Background

A research project, "National Park Service Coastal Visitor Impact Monitoring" was initiated formally in September 2002. As proposed, this is a three-phase study to test candidate variables for future visitor impact monitoring programs at seven important coastal areas managed by the National Park Service (NPS). These areas are as follows:

Assateague Island National Seashore, Maryland
Thomas Stone National Park, Maryland
Fire Island National Seashore, New York
Gateway National Recreation Area, New York
Sagamore Hill National Historic Site, New York
George Washington Birthplace National Monument, Virginia
Colonial National Historic Park, Virginia

Specifically, this "Phase 2 Preliminary Project Report" summarizes the findings from the initial phases of the project and includes 1) identification of network wide monitoring questions and major impacts; 2) a summary of the scoping results (manager interviews and site visits); 3) conceptual models of visitor impacts in coastal parks and 4) a prioritized list of candidate variables. Other findings on the project to date such as a scientific literature review of coastal visitor impacts and full reports from extensive site visits and manager interviews can be found in the Phase 1 Final Report (Monz et al., 2003)

## II- Network-Wide Monitoring Questions to be Addressed by Visitor Impact Monitoring

Considerable research has been conducted over the last 35 years on the consequences of recreational activities on natural resource conditions (Leung and Marion, 2000). This project will build on this knowledge and on the findings of similar monitoring projects (Marion and Cahill 2003) to address the following monitoring questions:

1) Which of the NPS areas as listed above are in need of visitor monitoring and visitor impact monitoring programs?
2) What are the management areas of critical concern where current or potential visitor activities threaten resource quality and compromise resource protection objectives?
3) In areas of critical concern, how is the type, amount and distribution of visitor use changing over time?
4) In areas of critical concern, what is the type and extent of visitor impacts to soil, vegetation and wildlife resources and how are these impacts changing over time?

This project is part of the NPS Vital Sign Program that was created for monitoring conditions of important natural resource variables indicative of ecosystem health and resource integrity. Visitors to coastal parks are engaged in a wide array of recreation

activities, most of which generate some level of impact. While visitor activity impacts may occur in many areas, impacts occurring within sensitive, natural/pristine or protected zones are of most concern because of the ecological and social value of these areas. Monitoring visitor impacts in these areas is consistent to the objectives of Vital Sign Program and would provide most valuable input to the Program as the impacts may constitute a significant threat to ecological health. This approach parallels the efforts at Cape Cod National Seashore (Marion and Cahill, 2003) and is supported by the findings of the Visitor Use Management Working Group of the Coastal Monitoring Network (Marion, et al., 2001)

## III- Summary of Scoping Results and Major Visitor Impacts

Visitor impacts to coastal resources are a significant concern to managers in all areas visited, although the degree of concern and the potential for significant impact is highly area dependent. For example, Gateway National Recreation Area, located in the New York City metropolitan area, sees over 8 million visits per year, with many visitors engaged in traditional beach activities such as swimming, sunbathing and sport fishing. In many cases, the popular sites for many of these activities are in proximity of areas managed for high resource protection. Conversely, at Sagamore Hill National Historic Site the majority of visits occur in the museum facilities, with very little current activity on the trails and the small barrier island area. Given these differences some elements of a comprehensive program of visitor impact monitoring may be areas specific, but for the purposes of this project and report, the commonalities of visitor impacts across network parks are emphasized. More site-specific monitoring recommendations, are highlighted in the Phase 1 report (Monz et al., 2003)

For the purpose of this study, we have identified two categories of visitor impact concerns 1) those applicable to the development of monitoring indicators in the context of this study (*Study Impact Concerns*) and 2) those beyond the scope of this study but raised by managers (*Additional Impact Concerns*). In general, impact concerns deemed beyond the scope of this study are primarily in front country areas or in areas of concentrated visitor use where resource monitoring would be of little management utility. Concerns of both types are mentioned and discussed in this section in order to provide a full summary of the scoping results.

1) Trampling impacts to vegetation and soils. All areas reported and we observed both current and potential impacts to dune and upland vegetation communities as a consequence of day and overnight use. Trampling is primarily caused by foot traffic, in areas where visitors are dispersing and traveling off established trails and boardwalks. In Colonial NHP, mountain biking use is also the source of vegetation and soil disturbance and throughout the parks, illegal ORV use can also result in these impacts. In most cases, managers report that little if any information exists on the location and extent of these impacts and whether impacts are changing over time. In some cases these impacts are localized, in point areas that attract visitors (i.e., campsites, coastal access points for fishing) and off hardened or resistant substrates (i.e., boardwalks and sand, respectively).

In other cases these concerns are more widespread, such as the impacts of beach visitors to coastal sea beach amaranth, or the proliferation of trails from beach areas on to the dune ecosystems.

2) Wildlife Impacts. Although managers raised some area specific wildlife impact issues, two overall concerns were raised by managers at several areas:

    a. The impact of visitors on piping plover (*Charandrius melodus*) and other beach nesting birds. Piping plovers and other seabird species occupy sand beaches and tidal flats and their numbers have been declining in recent years due to the extensive beach disturbance. The vast majority of visitors to these areas are primarily interested in beach recreation and consequently there exists an ever present possibility of impacts to these species. Although significant management efforts are generally in place to limit visitor disturbance and preserve habitat during nesting season, it is not clear in all cases as to the level of visitor compliance with exclosures or the degree to which visitors in adjacent areas are causing a wildlife disturbance response.
    b. Illegal harvesting and interaction with wildlife. Assateague and Gateway have concerns about the harvesting of fish, crabs, clams, and horseshoe crabs. Gateway experiences the illegal poaching of these animals and managers do not know the extent of impact caused or exactly how to prevent such activities. Managers at Assateague are concerned with the feeding and contact that visitors have with the wild horses.

3) Off Road Vehicle (ORV) Use. Managers at Assateague, Gateway and Fire Island have raised concerns about the impacts of ORVs to coastal dune flora and fauna. At each of these areas, ORVs are limited to designated zones, specific trails and/or travel corridors. In most cases total numbers of ORVs are limited by permit systems. Manager's observations would suggest that the nature and extent of ORV use has changed substantially at these areas over the last 10-20 years with increases in numbers of visitors and shifts in visitor activity preferences. At Assateague, for example, previous ORV use was limited to a large extent to visitors engaged in sport fishing activities. As such, visitors would drive to an area above the tide line and park. Recently with the popularity of sport utility vehicles, more visitors are coming just to drive the beach, picnic, have campfires, swim or to day hike into the nearby dune and forest communities. Given the scope and extent of this project, we will not be developing monitoring indicators to address specific issues within the designated ORV zones, trails or corridors. Monitoring protocols will address any impacts in natural areas adjacent to ORV zone where visitors may be traveling on foot or (illegally) by vehicle.

4) Trash. The presence of trash on the beaches, marshes and other areas is a ubiquitous and constant management concern. In addition to the obvious impact to the visitor experience, concerns have been raised as to the effects of trash on wildlife. Many areas have active programs in beach cleaning, which is effective in

some cases. Trash represents a difficult monitoring issue since much of the trash is floating debris from the nearby metropolitan areas and therefore does not originate from park visitors.

## IV- Conceptual Model Approach to Indicator Selection

The selection of accurate and appropriate vital signs of resource conditions is essential to the development of any program of long-term monitoring. For this project, a two-step process informed the selection of vital sign indicators. First, conceptual models of the interactions of agents of change, stressors and ecosystem responses were developed for visitor impacts in coastal ecosystems and for the soil, vegetation and wildlife responses within those ecosystems. This conceptual model approach is helpful to illustrate the mechanisms of impact and the ecosystem-level consequences of those impacts and is similar to other approaches of ecological indicator selection adopted by the NPS. (Crabtree and Bayfield, 1998; Dale and Beleyer, 2001; Olsen et al., 1992). Second, a matrix of desirable vital sign attributes was developed to aid the decision making process of identifying specific feasible indicators. This section describes the conceptual model approach (Figs. 1-4) while the attribute matrix is described in the final section.

### A. Overall Ecosystem Model

For the overall ecosystem model (Fig. 1), three agents of change are identified: visitor/recreation use, resource consumption and land use. Marion et al., (2001) identified a range of visitor activities in coastal parks and these include jogging, hiking, volleyball, sunbathing, off-road vehicle use, camping, dog walking, etc. Each of these forms of activities can result in unique impacts. Resource consumption is defined as any activity leading to a direct harvest of flora and fauna including fin fishing, shell fishing, hunting, and collecting. The land use component includes direct effects as a consequence of visitor activities such as facility development, and access development. These three agents result in four major stressors including over-harvesting, invasive species introductions, biotic disturbance, and altered physical environment. The stressors lead to changes within the ecosystem such as, changes in the ecosystem structure or changes in the physical or chemical environment.

### B. Vegetation Disturbance

For the vegetation model (Fig. 2), five specific agents are identified, visitor density (the amount of visitors concentrated in one area), visitor distribution (spatial/temporal), visitor activity type (behavior and type of recreation activity), and visitor transportation (by what means they are traveling in the area of concern), and resource consumption (harvest of plant or plant parts).

Trampling, stem breakage, and collecting of plants or plant parts cause damage to plant structures and may result in displacement of plant species or changes in plant populations. The extent of damage depends on the degree of each agent of change. Through these disturbances, changes in plant populations occur, including direct

mortality, reduced vigor, reduced reproduction, and species cover loss. These stressors result in four major ecosystem responses: direct introduction of plant species, species composition change, changes in competitive interactions, and changes in primary production.

**C. Soil Disturbance**

Four agents of change can lead to soil disturbance: visitor density, visitor distribution, visitor activity type, and visitor transportation (Figure 3). These agents lead to soil disturbance, which occurs through trampling, scuffing, displacement of soil, vehicle tracks, etc. The ecosystem responds to these stressors by soil compaction, soil exposure, and reduction in air, water, and root permeability. The exposure of soil results in erosion, loss of organic matter, loss of soil nutrients, and changes in the soil texture. Changes in soil biota and nutrient cycling occur when there is a reduction in air, water and root permeability and results in erosion, loss of organic matter, loss of soil nutrients, and changes in the soil texture.

**D. Wildlife Disturbance**

As in the vegetation model, five agents of change can lead to wildlife disturbance (Fig. 4). The three resulting stressors direct disturbance, habitat modification, and pollution/trash can cause wildlife to alter their behavior or may alter the energy balance of the affected individuals. The ecosystem consequences of these stressors can be direct mortality of individuals in the affected population, altered productivity of the population (increase or decrease) and species displacement from preferred habitat. Ultimately species composition and population numbers are affected as well as competitive interactions within and among species.

*Figure 1.* Overall model of visitor impacts to coastal ecosystems

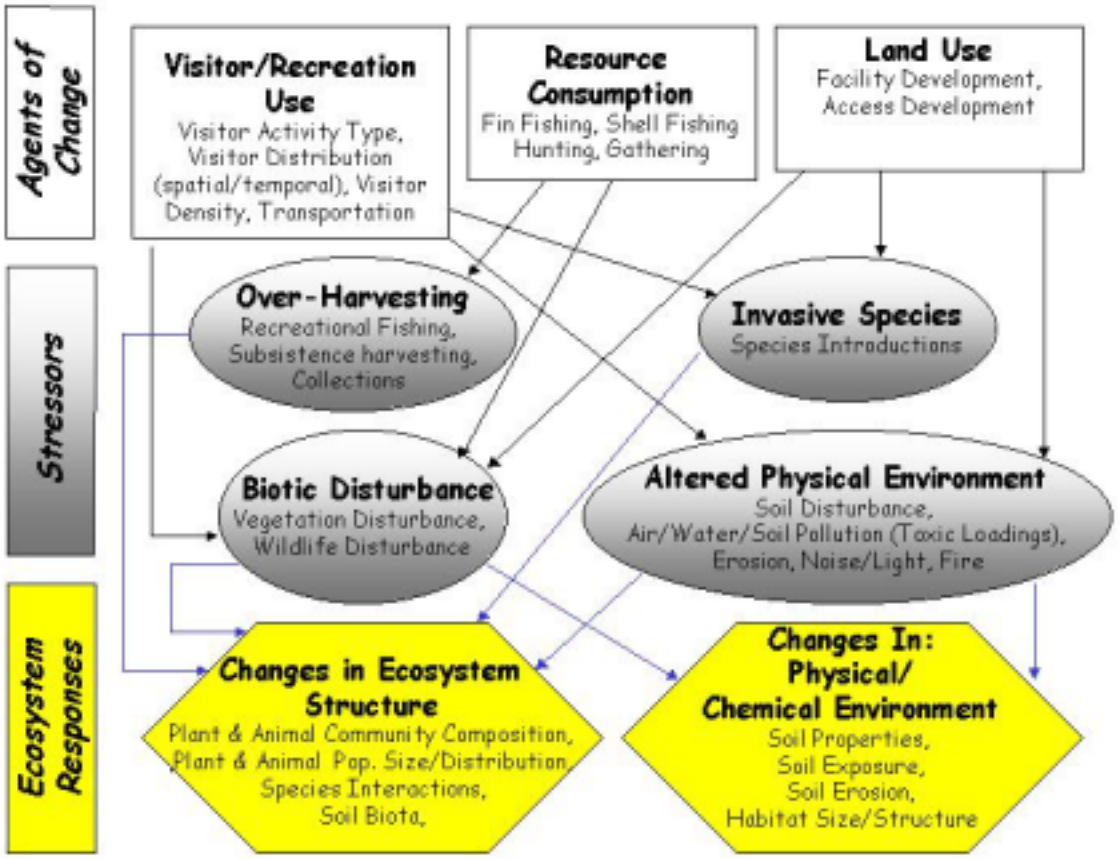


*Figure 2*. Conceptual ecosystem model of visitor impacts to vegetation.

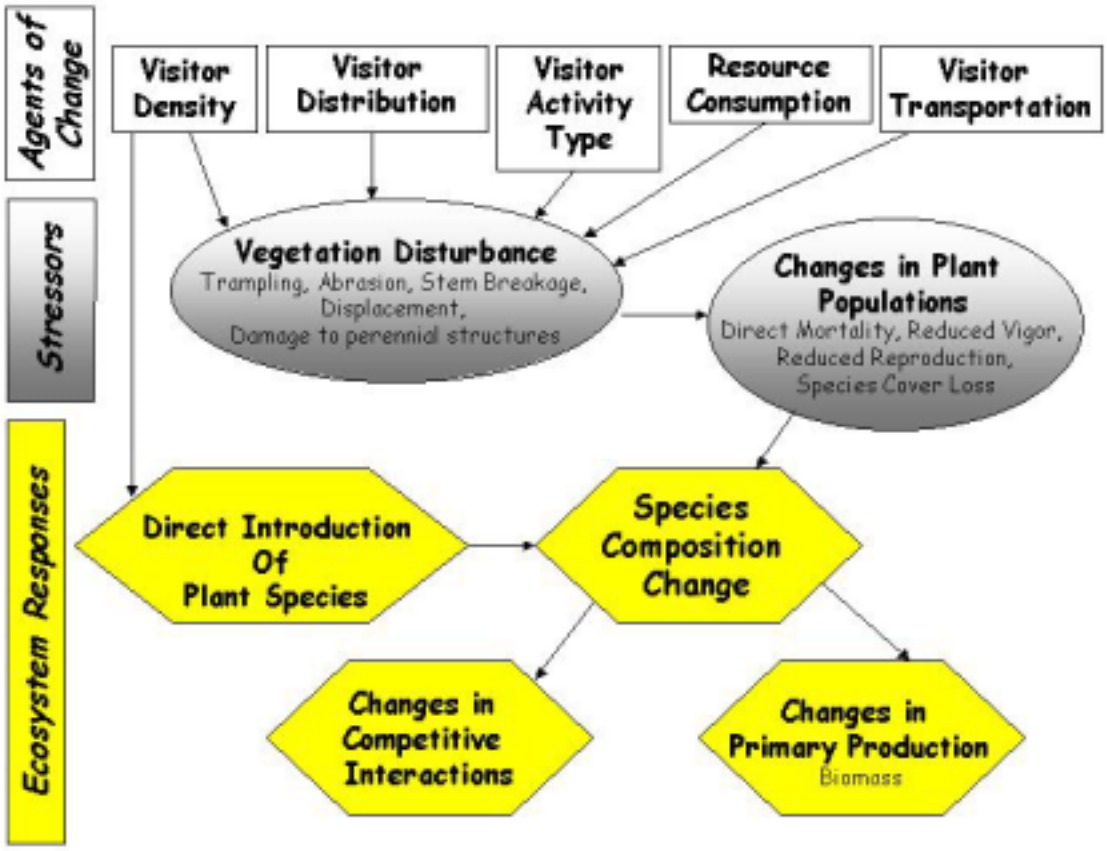


*Figure 3.* Visitor impacts to soils in coastal environments

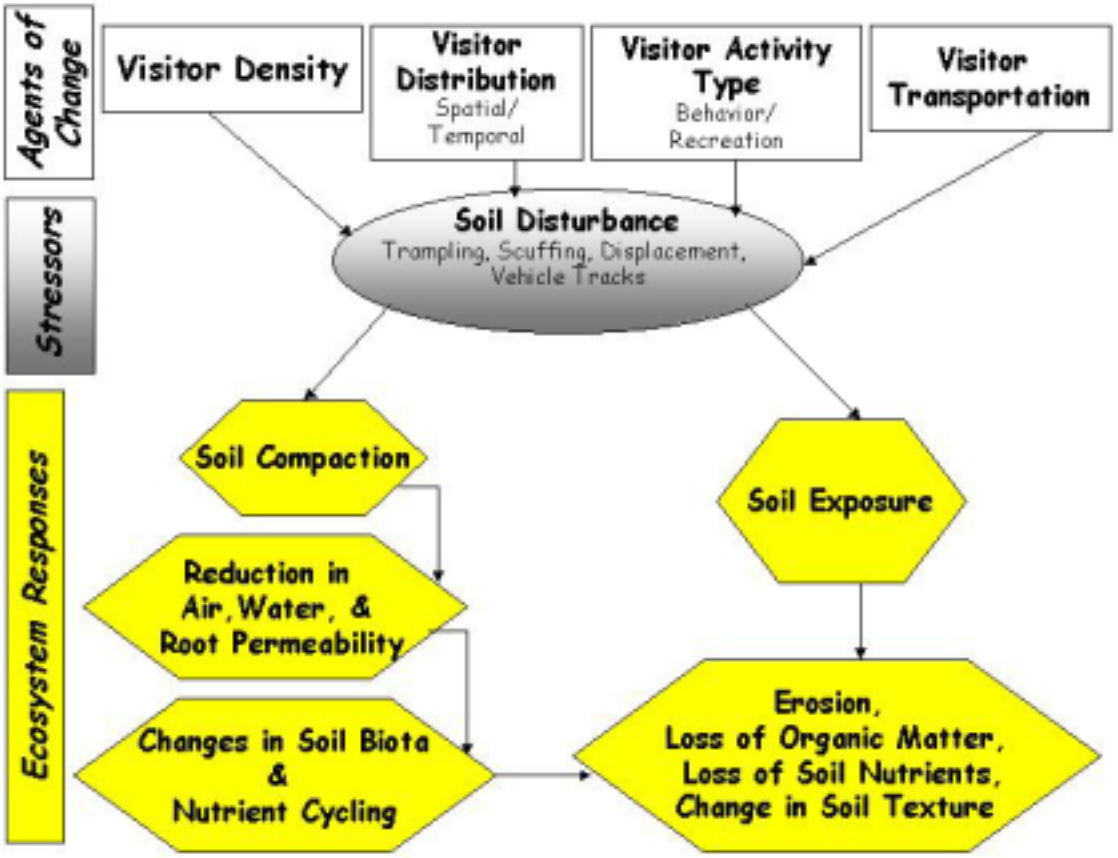
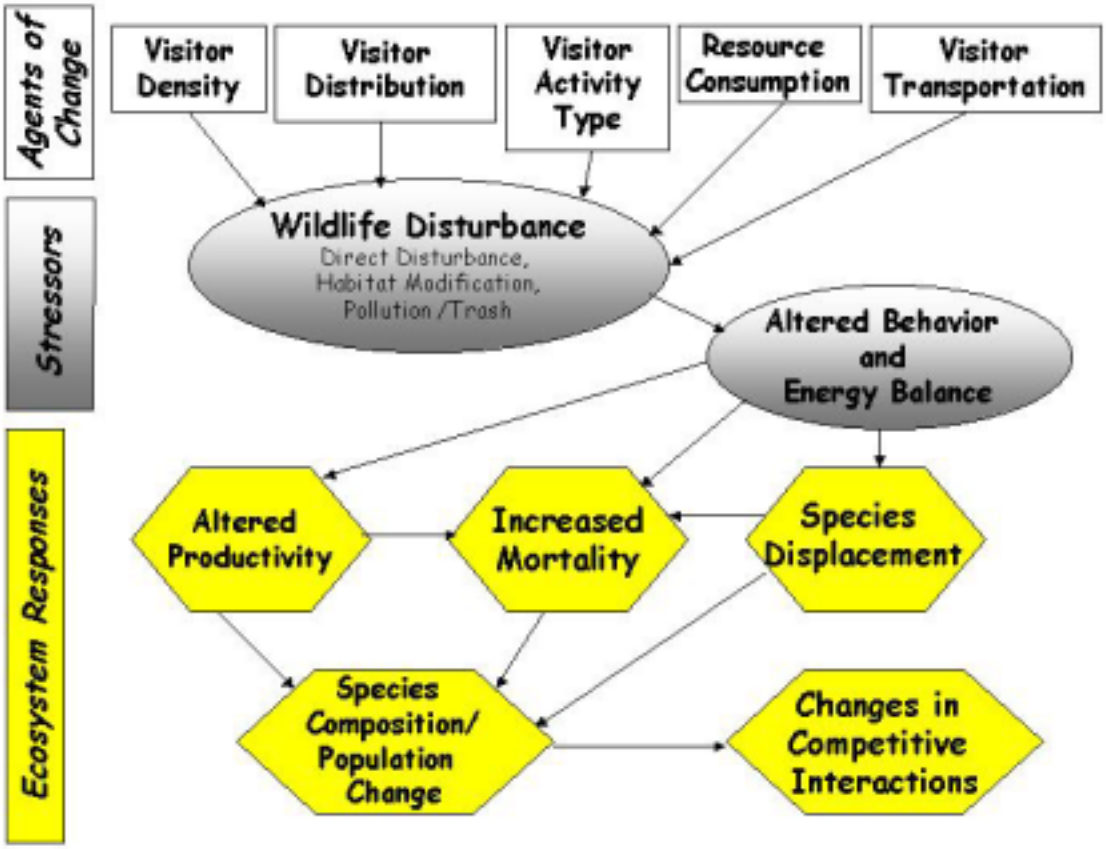


*Figure 4*. Visitor impacts to wildlife in coastal ecosystems



## V. Candidate Vital Signs

Vital signs, sometimes referred to as ecological indicators, are defined as measurable features of the environment that provide insights into the state of the ecosystem. The National Park Service strives to identify and monitor vital signs of environmental health in parks as a means of sustaining the health of park resources and managing threats to their well being proactively. Monitoring vital signs provides the foundation for this approach by evaluating efficacy of management actions and by warning of impending threats to park ecosystems (Fancy, 2003).

Natural resource impacts associated with visitor use in the form of outdoor recreation, tourism or ecotourism have been identified as one of the five major ecological threats to the NPS units within the Northeast Coastal and Barrier Network (Milstead, 2003). Accordingly, vital sign indicators of visitor impacts need to be developed as an integral part of the overall Network's vital signs monitoring program. The process of indicator development includes indicator identification, indicator ranking and selection, sampling strategy determination, and field testing and verification. The following describes the first two steps of the indicator development process and concludes with a prioritized list of candidate vital sign indicators.

### A. Identifying Candidate Vital Signs

Throughout the Phase 1 research of this project a variety of sources were consulted to identify candidate vital signs of visitor impacts for the Network. These sources included scientific literature (Ingle et al., 2003; Leung and Marion 2000), experiences from recent studies within the Network or nearby areas (Manning, Leung and Budruk, 2003; Marion and Kahill 2003), results from the Visitor Use Monitoring Work Group Report (Marion et al., 2001), results from interviews with park staff (Monz et al., 2003; Section III this report), and the conceptual models developed for visitor impacts (Section IV this report). These candidate vital sign indicators represent three major components of visitor impact conceptual models, namely agents of change or pressure, stressors and ecosystem responses (Crabtree and Bayfield, 1998; Dale and Beleyer, 2001; Olsen et al., 1992). A summary of the identified candidate vital signs is provided in Tables 1 to 3.

**Table 1.** Candidate vital signs, monitoring approaches and specific measures for the agents of change in the natural zones.

| Candidate Vital Sign | Monitoring Approach | Vital Sign Indicator Measure(s) |
|---|---|---|
| Visitor Activity Type | Managers Survey<br>Direct Field Observation<br>Entry Point Visitor Survey | Dominant activity type;<br>Composition of different activity types |
| Visitor Density | Managers Survey<br>Direct Observation<br>Trail Counters | Scale Ratings of use Frequency<br>Observed number of visitors by activity type<br>Number of hikers along selected trail segments |
| Distribution of Visitor Use | Managers Survey<br>Direct Observation<br>Trail Counters | Location and extent of recreational use |

**Table 2**. Candidate vital signs, monitoring approaches and specific measures for soil and vegetation degradation in natural zones

| Candidate Vital Sign | Monitoring Approach | Vital Sign Indicator Measure(s) |
|---|---|---|
| Vegetation Loss/ Soil Exposure | Direct On-site Measurement at recreation sites and along trails<br>Air photo image processing | Relative cover loss (%)<br>Changes in soil exposure (%) |
| Vegetation Compositional Change | Direct On-site Measurement at recreation sites and along trails | Individual Species Cover (%)<br>Presence/Absence of invasive plant species |
| Social Trail Formation | Direct On-site Assessment and Mapping<br>Air photo image processing | Location, extent and mapping of visitor-created trails |
| Unofficial Site Formation | Direct On-site Assessment and Mapping<br>Air photo image processing | Location, extent and mapping of visitor-created sites |
| Shoreline Disturbance | Direct On-site Assessment and Mapping in sensitive areas | Location, extent and mapping of shoreline disturbance sites |
| Disruption of Submerged Aquatic Vegetation | Direct On-site Assessment | Location and Extent of disturbance |

**Table 3**. Candidate vital signs, monitoring approaches and specific measures for wildlife disturbance in natural zones

| Candidate Vital Sign | Approach | Vital Sign Indicator Measure(s) |
|---|---|---|
| Disturbance type | Direct Behavior Observation | Type of visitor activities affecting wildlife (i.e., shorebirds) |
| Disturbance time | Direct Behavior Observation | Length of time of disturbance events |
| Attraction Behavior | Direct Behavior Observation | Number of occurrences of wildlife feeding<br>Number of occurrences of attraction behavior |

B. Criteria for Ranking Vital Signs

Due to time, monetary and other logistical constraints, not all of the above candidate vital signs can be implemented in the Network's vital sign monitoring program. A systematic process of ranking and selecting candidate vital sign indicators is therefore an essential next step.

Selection criteria of ecological and sustainability indicators in general (Consulting and Audit America, 1995; Jackson et al., 2000) and visitor impact indicators specifically (Belnap 1998; GYWVU 1999, Manning, Leung and Budruk, 2003) were reviewed. It resulted in thirteen selection criteria proposed for this project (Table 4). Four are required criteria that must be met by the candidate indicator if it is to be considered for selection. The remaining nine are optional criteria that are used for evaluating the desirability of candidate indicators even though they may have met the required criteria.

**Table 4.** Evaluation Criteria for Candidate Vital Sign Indicators*.

| CRITERIA | DESCRIPTION |
|---|---|
| **Low measurement impacts** | The indicator can be measured with no or minimal level of ground disturbance |
| **Reliable/Repeatable** | The measurements of indicator by different field staff would show reasonable agreement |
| **Correlation with use** | The indicator is directly related to visitor use with good level of correlation |
| **Ecologically relevant** | The indicator must have conceptual relevance to concerns about ecological condition, i.e., it must be a component of the appropriate conceptual model. It must reflect an important change of resource condition that would lead to significant ecological or social consequences |
| **Respond to impacts** | Change of resource condition can occur promptly after impacts are introduced |
| **Respond to management** | Resource conditions can be manipulated by management actions |
| **Easy to measure** | Field measurements are relatively straightforward to perform with minimal level of equipment needed |
| **Low natural variability** | Indicator has a limited level of spatial and temporal variability |
| **Large sampling window** | Field measurements can take place in most of the times in a year |
| **Cost effective** | Measurements of indicator are inexpensive. Little additional cost to management. Data gathered benefit management |
| **Easy to train for monitoring** | Field staff with no prior knowledge of field procedures can be easily trained to perform such procedures |
| **Baseline data** | There are existing data on the indicator, preferably with the use-impact link established |
| **Response over different conditions** | Impacts can be seen while still relatively slight |

* The first four criteria are required while the remaining nine are desirable criteria. These criteria were adapted from Belnap (1998), Consulting and Audit Canada (1995), GYWVU (1999) and Manning et al. (2003).

C. Ranking Results: Prioritized List of Candidate Vital Signs

All twelve candidate vital signs identified in Section A were evaluated against the thirteen criteria described in preceding section. Table 5 provides a summary of the evaluation process in form of a two-dimensional matrix. The result is presented as a prioritized list of candidate vital signs (Table 6). High priority indicators are those to be recommended for adoption in the Network's vital signs monitoring program, while the low priority indicators will not be recommended. After selecting vital sign indicators specific indicator measures will be evaluated and compared based on their cost effectiveness and performance.

**Table 4.** Evaluation Matrix of Candidate Vital Sign Indicators for Visitor Impacts.

| SELECTION CRITERIA* | CANDIDATE VITAL SIGN INDICATORS | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *Visitor Activity Type* | *Visitor Density* | *Dist. of Visitor Use* | *Vegetation Loss/Soil Exposure* | *Vegetation Composition Change* | *Social Trail* | *Unofficial Sites* | *Shoreline Disturb.* | *Submerged Aquatic Veg.* | *Wildlife Disturb. Type* | *Wildlife Disturb. Time* | *Attraction Behavior* |
| **Low measurement impacts** | + | + | + | + | + | + | + | + | + | + | + | + |
| **Reliable/Repeatable** | 0 | 0 | 0 | 0 | 0 | 0 | + | 0 | 0 | 0 | 0 | 0 |
| **Correlation with use** | + | + | + | + | + | + | + | ? | ? | + | + | + |
| **Ecologically or socially relevant** | + | + | + | + | + | + | + | + | + | + | + | + |
| **Respond to impacts** | + | + | + | + | + | + | + | + | ? | + | + | + |
| **Respond to management** | + | + | + | + | + | + | + | + | + | + | + | + |
| **Easy to measure** | + | + | 0 | + | ? | + | + | + | + | 0 | 0 | + |
| **Low natural variability** | + | + | + | + | + | + | - | 0 | 0 | ? | ? | ? |
| **Large sampling window** | + | + | + | + | + | + | + | + | + | + | + | + |
| **Cost effective** | 0 | 0 | 0 | 0 | 0 | 0 | + | + | + | + | + | + |
| **Easy to train for monitoring** | + | + | + | + | + | 0 | + | 0 | ? | + | 0 | 0 |
| **Baseline data** | 0 | 0 | - | 0 | - | 0 | - | - | - | 0 | 0 | 0 |
| **Response over different conditions** | + | + | + | + | ? | + | + | ? | ? | ? | ? | ? |
| **Priority** | M | M | **H** | **H** | M | **H** | **H** | L | L | M✘ | M✘ | **H** |

* The first 4 criteria are required while the other 9 are desirable criteria.

+ = Criterion satisfied 0 = criterion partially satisfied (or varies by zone/area) - = criterion not satisfied ? = questionable/undecided

n.a. = not applicable

**Table 5**. A prioritized list of candidate vital signs.

| Priority | Candidate Vital Signs |
|---|---|
| *High* | 1) Distribution of Visitor Use |
| (Recommended for Adoption in CBN Vital Signs Monitoring Program) | 2) Vegetation Loss/ Soil Exposure |
| | 3) Social Trail Formation |
| | 4) Unofficial Site Formation |
| | 5) Attraction Behavior |
| *Medium* | 6) Visitor Activity Type |
| | 7) Visitor Density |
| | 8) Vegetation Composition Change |
| | 9) Wildlife Disturbance Type |
| | 10) Wildlife Disturbance Time |
| *Low* | 11) Shoreline Disturbance |
| (Not Recommended for Adoption in CBN Vital Signs Monitoring) | 12) Submerged Aquatic Vegetation |

Literature Cited

Belnap, J. 1998. Choosing indicators of natural resource condition: A case study in Arches National Park, Utah, USA. Environmental Management. 22(4): 635-642.

Consulting and Audit Canada 1995. What Tourism Managers Need to Know: A Practical Guide to the Development and Use of Indicators of Sustainable Tourism. Madrid: World Tourism Organization.

Crabtree, B. and N. G. Bayfield. 1998. Developing sustainability indicators for mountain ecosystems: A study of the Cairngorms, Scotland. Journal of Environmental Management. 52(1): 1-14.

Dale, V. and S. C. Beyeler. 2001. Challenges in the development and use of ecological indicators. Ecological Indicators 1: 3-10.

Fancy, S. 2003. Monitoring Natural Resources in our National Parks. Online at http://www.nature.nps.gov/im/monitor/ [Last Visited: July 3, 2003]

GYWVU (Greater Yellowstone Winter Visitor Use Management Working Group) 1999. Winter Visitor Use Management: A Multi-Agency Assessment. Final Report of Information for Coordinating Winter Recreation in the Greater Yellowstone Area. Jackson, WY: USDI National Park Service.

Ingle, C., Y.-F. Leung, C. Monz, and H. Bauman. 2003. Monitoring visitor impacts in coastal national parks: A review of techniques. In: Proceedings of the 12th George Wright Society Conference on Resource Management in Parks and on Public Lands; Apr.14-18, 2003; San Diego, CA. Hancock, MI: The George Wright Society. In Press.

Jackson, L. E., J. C. Kurtz, and W. S. Fisher. 2000. Evaluation Guidelines for Ecological Indicators. USEPA. Publication No. EPA/620/R-99/005.

Manning, R. E., Y.-F. Leung and M. Budruk. 2003. Boston Harbor Islands National Park Area – Carrying Capacity Study Final Report. In Prep.

Marion, J. L., C. Roman, B. Johnson, and B. Lane. 2001. Summary of Visitor Use Management Working Group, Vital Sign Workshop for the North Atlantic Coastal Park Network, Gateway National Recreation Area, NY. 7pp.

Marion, J. L. and K. Cahill. 2003. Design and testing of protocols for monitoring visitor use and resource impacts at Cape Cod National Seashore. NPS project report. 33 pp.

Milstead, B. 2003. Conceptual modeling for vital signs monitoring in Northeast Coastal and Barrier Network. PowerPoint presentation. (need to confirm title).

Monz, C., Y.-F. Leung, H. Bauman and C. Ingle. 2003. National Park Service Coastal Visitor Impact Monitoring: Phase 1 Project Report**.** Final report submitted to USDI National Park Service, Northeast Coastal and Barrier Network.

NPS Natural Resource Program Center. 2003. Handbook for Monitoring Vital Signs in National Parks. Online at http://www.nature.nps.gov/im/monitor/handbook.htm [Last Visited: July 3, 2003]

Olsen et al. 1992. The indicator development strategy for the environmental monitoring and assessment program. EPA/600/3-91/023